Geotechnical Engineering Report

Rostrum Renovations – Fort Smith National Cemetery

Fort Smith, Kansas

September 30, 2014

Project No. B3145221

Prepared for:

FourFront Design, Inc.
517 Seventh Street
Rapid City, South Dakota
Indianapolis, Indiana

Prepared by:

Terracon Consultants, Inc.
Springfield, Missouri

September 30, 2014

FourFront Design, inc.
517 Seventh Street
Rapid City, South Dakota

Attn: Mr. Erik Heikes, PLA, LEED, AP
P: 605-342-9470
E: eheikes@4front.biz

Re: Geotechnical Engineering Report
Rostrum Rennovations at Fort Scott National Cemetery
Fort Scott, Kansas
Terracon Project Number: B3145221

Dear Mr. Heikes:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the Rostrum Renovations at Fort Scott National Cemetery in Fort Scott, Kansas. This study was performed in general accordance with Work Order number PB314213g signed August 17, 2014. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

R. Todd Hercules, E.I.
Staff Geotechnical Engineer

Ty G. Alexander, P.E.
Senior Associate
Kansas P.E.: 20314

Enclosures
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1 – File

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EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the Rostrum Renovations at Fort Scott National Cemetery located in the northwest corner of the intersection of Williams Street and Kansas Street in Fort Scott, Kansas. Two (2) borings, designated B-1 and B-2 were performed to depths of approximately 4½ to 5 feet below the existing ground surface. The following geotechnical considerations were identified:

- Shallow weathered rock was encountered at depths of 3 feet. Rock chippers and hammers may be required during footing excavations and site grading. The rostrum foundations should bear all on soil/engineered fill or all on bedrock. If shallow bedrock is encountered during footing excavations, the footings should either be extended to bear all on bedrock or the bedrock should be excavated a minimum of 2 feet and replaced with a properly compacted structural fill.

- Demolition of the existing rostrum should include removal of all above and below grade elements including slabs, foundation walls, and footings. Any existing utilities should also be properly abandoned and/or relocated. This should include removal of all poorly compacted trench backfill extending into the proposed building area. Excavations created by demolition and removal of existing features should be backfilled with engineered fill that is placed and compacted as recommended in this report.

- The fat clay (CH) soils encountered in the borings are high in plasticity and prone to volume change with variations in moisture content. For this reason, we recommend a 24-inch thick Low Volume Change (LVC) zone be present or constructed beneath grade-supported floor slabs.

- The 2009 International Building Code (IBC) seismic site classification for this site is C.

The professional opinions and recommendations presented in this report are based on evaluation of data developed by testing discrete samples obtained from widely-spaced borings. Site subsurface conditions have been inferred from available data, but actual subsurface conditions will only be revealed by excavation. So that variations in subsurface conditions which may affect the design can be addressed as they are encountered, we recommend that Terracon be retained to observe excavation and perform tests during the site preparation, earthwork and foundation construction phases of the project.

This executive summary should not be separated from or used apart from this report. This report presents fully developed recommendations and opinions based on our understanding of the project at the time the report was prepared. The report limitations are described in the **GENERAL COMMENTS** section of this report.

GEOTECHNICAL ENGINEERING REPORT
ROSTRUM RENOVATIONS AT FORT SCOTT NATIONAL CEMETERY
FORT SCOTT, KANSAS
Terracon Project No. B3145221
September 30, 2014

1.0 INTRODUCTION

A geotechnical exploration has been performed for the Rostrum Renovations at Fort Scott National Cemetery in Fort Scott, Kansas. Two (2) borings, designated B-1 and B-2 were performed to depths of approximately 4½ to 5 feet below the existing ground surface. Logs of the borings along with a Topographic Map, Location Map, Geologic Map, and Boring Location Diagram are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- earthwork
- slab design and construction
- seismic considerations
- foundation design and construction

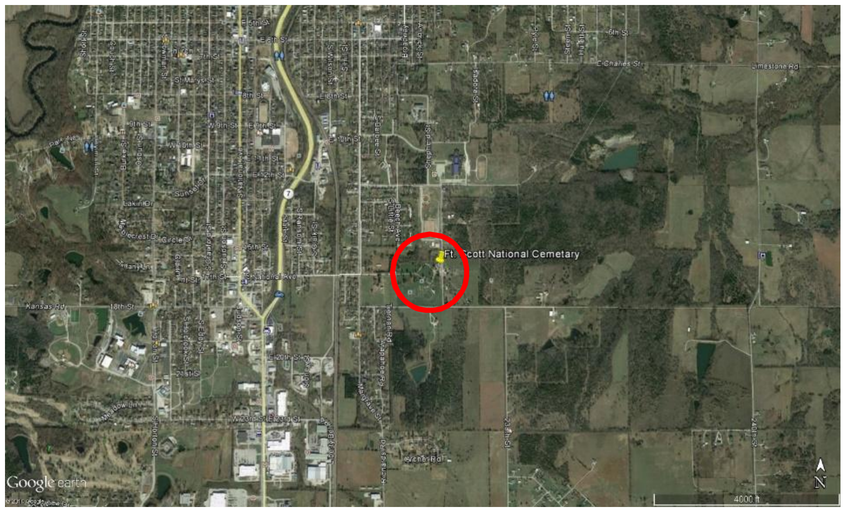
2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibit A-5: Boring Location Diagram
Building information	Addition and renovation to existing rostrum will include construction of a speaking platform with a green roof. The green roof is Anticipated to be wood or metal framed founded on conventional shallow spread footings. Slabs will be constructed on-grade.
Finished floor elevation	Not provided – assumed to be at or near existing grade
Maximum building loads (assumed)	Columns: 60 kips Walls: not anticipated Slabs: 150 psf
Site grading	A proposed grading plan is not available. However, based on the relative elevations of our boring locations, we anticipate there to be less than 3 feet of cut/fill
Below-grade walls	None anticipated

Item	Description
Retaining walls	None anticipated

2.2 Site Location and Description

Item	Description
Location	NEC of Kansas Road and Williams St. – Fort Scott, Kansas.  Lat:/Long.: 37°49'19.15"N, 94°41'32.23"W
Existing improvements	Existing structures, access drives, parking, landscaping. 
Current ground cover	Area in proposed addition is covered with landscape grass.
Existing topography	Not provided. Based on information available on Google Earth Pro, site appears to slope moderately with drainage to the southwest.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Stratum	Approximate Depth to Bottom of Stratum (feet)	Boring Locations	Material Description	Consistency/ Density
Surface	0.3 to 0.7	All	Topsoil	n/a
1	3	All	Fat Clay, with traces of organics, and gravel	Very Stiff to Hard
2	Undetermined [1]	All	Weathered Limestone	N/A

1. Borings B-1 and B-2 were terminated within this stratum at depths of approximately 4½ to 5 feet.

Conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report.

3.2 Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. At the time of drilling no free water was noted within the borings. The absence of observed water does not mean that the boring terminated above groundwater. Due to the low permeability of some of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole in these materials. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. In addition, perched water can develop over low permeability soil strata and on the limestone bedrock. Therefore, groundwater levels during construction or at other times in the life of the structures may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

3.3 Geology

According to the “Surficial Geology of Kansas” map created by the Kansas Geological Survey and The University of Kansas in 2008, the subject site is located within the Desmoinesian

Formation's Marmaton Group. The bedrock in this area primarily consists of varying layers of shale and limestone. According to the USGS the Marmaton group can also contain minor amounts mudstone, sandstone, and coal.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the results of the subsurface exploration, laboratory testing, and our analyses, it is our opinion that the rostrum renovations can be supported on shallow foundations bearing on suitable native clay, newly placed compacted structural fill, or bedrock. Geotechnical considerations for this project include:

- Shallow bedrock considerations; and
- Presence of high plasticity clays.

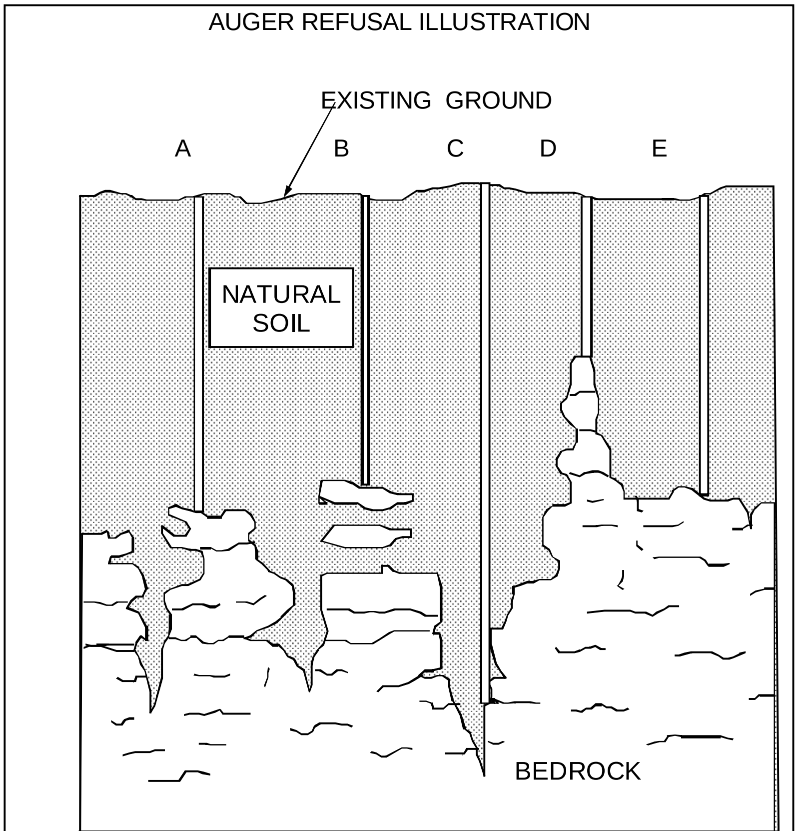
4.1.1 Shallow Bedrock Considerations

Auger and/or sampler refusal on apparent intact bedrock was encountered in each of the borings at depths between about 4½ and 5 feet below present grades. Prior to auger refusal, about 1½ to 2 feet of weathered bedrock was encountered in Borings B-1 and B-2. The weathered rock was penetrated with the augers with some effort. Site grading and excavations for the foundations and utilities will likely encounter bedrock.

Weathered rock that is penetrated with drilling augers can typically be excavated with large excavation equipment fitted with rock teeth using concentrated effort or ripped with large bulldozers. Layers of intact rock may be present within the weathered zones, which could require breaking with pneumatic rock breakers or blasting. Excavations in weathered rock often result in larger excavations than in soils, which subsequently require more backfill.

Auger refusal is defined as the depth below the ground surface at which a boring can no longer be advanced with the soil drilling technique being used. Auger refusal is subjective and is based upon the type of drilling equipment used, the types of augers being used, and the effort exerted by the driller. Auger refusal can result on the upper surface of discontinuous bedrock (A), slabs of unweathered rock suspended in the residual soil matrix or "floaters" (B), in widened joints that may extend well below the surrounding bedrock surface (C), on rock "pinnacles" (D) rising above the surrounding bedrock surface, or on the upper surface of continuous bedrock (E). These possible auger refusal conditions are illustrated in the below figure.

Depending on the finished floor elevation of the building, the rostrum foundations could bear all on soil (native or engineered fill), all on intact bedrock, or partially on soil and partially on bedrock. If the building foundations are either supported *all* on intact bedrock or *all* on soil, then the shallow foundations can bear directly on these materials. However, if the building foundations will be supported partially on soil and partially on bedrock, then when rock is encountered in footing excavations, we recommend that the footings be overexcavated 2 feet below the design bearing level into the bedrock. The overexcavation should also extend laterally a sufficient distance to provide room for installation of a bond break with the sides of the footing excavation. The overexcavation into the bedrock should be backfilled with compacted, densely-graded granular material as described in section **4.2.2 Material Requirements**. Compactive effort should be in accordance with recommendations provided in section **4.2.3 Compaction Requirements**. The purpose of the overexcavation is to reduce differential settlement due to differing bearing materials. Alternatively, in lieu of overexcavating bedrock and backfilling with soil, soils can be overexcavated until bedrock is encountered, and then backfilled with lean concrete.



THIS FIGURE IS FOR ILLUSTRATIVE PURPOSES ONLY AND DOES NOT NECESSARILY DEPICT THE SPECIFIC BEDROCK CONDITIONS AT THIS SITE

When the proposed grading plan is available and prior to foundation construction, borings or auger probes could be performed to obtain more bedrock information. Linear interpolation of apparent bedrock elevations based upon the boring data is often used but can misrepresent actual rock removal quantities where such anomalies exist.

4.1.2 Swell Potential

We recommend a low volume change (LVC) zone be constructed beneath the at-grade slabs. Using an LVC zone as recommended in this report may not eliminate all future subgrade volume change and resultant slab movements. However, the procedures outlined herein should help reduce the potential for subgrade volume change. Existing soils can be left in place and compacted if they are tested during construction and meet LVC material requirements. Details regarding this LVC zone are provided in section **4.4 Grade-Supported Slab.**

4.1.3 General

We recommend that the exposed subgrade be thoroughly evaluated after stripping of any topsoil and at the base of all cut areas, but prior to the start of any fill operations. We recommend that the geotechnical engineer be retained to evaluate the bearing material for the foundations and subgrade soils. Subsurface conditions, as identified by the field and laboratory testing programs, have been reviewed and evaluated with respect to the proposed project plans known to us at this time.

4.2 Earthwork

4.2.1 Site Preparation

We anticipate construction will be initiated by the removal of landscaping, topsoil, and vegetation that may be present. Attention should be given to removing all loose or poorly compacted existing fill materials that are often located adjacent to foundation walls.

Any slabs, foundations, other structures, or utilities and associated backfill that are encountered during construction should also be removed to allow evaluation of the underlying soils. Stripping and excavation depths will likely vary across the site. In addition, care should be taken by contractors to protect all existing improvements to remain, such as pavements and utilities.

Fat clay soils should not be placed or present in the upper 2 feet below the planned bottom of slabs and other flatwork abutting the structure. Suitable materials in this 2-foot-thick zone should meet the LVC requirements defined in section **4.2.3 Material Requirements** of this report.

We recommend that the exposed subgrade be thoroughly evaluated by a geotechnical engineer prior placement of new fill. The soils on the site are sensitive to disturbance from construction equipment traffic, particularly during wet periods. Excessively wet or dry material should either be removed or moisture conditioned and recompacted. The exposed subgrade, including areas of existing undocumented fill, should be proof-rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a loaded tandem axle dump truck. If unsuitable areas are observed during construction, subgrade improvement will then be necessary to establish a suitable subgrade support condition. Subgrade stabilization is discussed in section **4.2.2 Soil Stabilization**.

4.2.2 Soil Stabilization

Methods of subgrade improvement, as described below, could include scarification, moisture conditioning and recompaction, removal of unstable materials and replacement with granular fill (with or without geosynthetics) and chemical stabilization. The appropriate method of improvement, if required, would be dependent on factors such as schedule, weather, the size of the area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm seasons and dry periods would help to reduce the amount of subgrade stabilization required.

If the exposed subgrade is unstable during proofrolling operations, it could be stabilized using one of the methods outlined below.

- **Scarification and Compaction** – It may be feasible to scarify, dry, and compact the exposed soils. The success of this procedure would depend primarily upon favorable weather and sufficient time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot, if the unstable soil is at or near groundwater levels, or if construction is performed during a period of wet or cool weather when drying is difficult.

- **Crushed Stone** – The use of crushed stone or crushed gravel is the most common procedure to improve subgrade stability. Typical undercut depths would be expected to range from about 6 to 30 inches below finished subgrade elevation. The use of high modulus geotextiles (i.e., engineering fabric or geogrid) could also be considered after underground work such as utility construction is completed. Prior to placing the fabric or geogrid, we recommend that all below-grade construction, such as utility line installation, be completed to avoid damaging the fabric or geogrid. Equipment should not be operated above the fabric or geogrid until one full lift of crushed stone fill is placed above it. The maximum particle size of granular material placed over geotextile fabric or geogrid should meet the manufacturer's specifications, and generally should not exceed 1½ inches.

- **Chemical Stabilization** – Improvement of subgrades with Portland cement, lime kiln dust, Code L, or class C fly ash could be considered for improving unstable soils. Chemical modification should be performed by a prequalified contractor having experience with successfully stabilizing subgrades in the project area on similar sized projects with similar soil conditions. Results of chemical analysis of the additive materials should be provided to the geotechnical engineer prior to use. The hazards of chemicals blowing across the site or onto adjacent property should also be considered. Additional testing would be needed to develop specific recommendations to improve subgrade stability by blending chemicals with the site soils. Additional testing could include, but not be limited to, evaluating various admixtures, the optimum amounts required, the presence of sulfates in the soil, and freeze-thaw durability of the subgrade.

Further evaluation of the need and recommendations for subgrade stabilization can be provided during construction as the geotechnical conditions are exposed.

4.2.3 Material Requirements

Materials that will be used as fill should be free of organic matter and debris. Frozen materials should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to Terracon for evaluation.

Fill Type[1]	USCS Classification	Acceptable Location for Placement
Lean Clay	CL (LL<50)	All locations and elevations, except as LVC material unless material explicitly meets LVC requirements.
Fat Clay[2]	CH (LL≥50)	> 24 inches below building finished grade
Well-graded Granular	GM [4]	All locations and elevations
Low Volume Change (LVC) Material [3]	CL (LL<45 & PI<22) GM [4]	All locations and elevations
On-site Soils	CH	>24 inches below building finished grade

1. Compacted structural fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to Terracon for evaluation.
2. Delineation of moderate to highly plastic clays should be performed in the field by a qualified geotechnical engineer or their representative, and could require additional laboratory testing. If fat clay fill material contains greater than 35% granular material retained on a ¾ inch sieve, it may be used in the 24-inch thick low volume change zone.
3. Low plasticity cohesive soil or granular soil having low plasticity fines. Material should be approved by the geotechnical engineer.
4. Similar to AB-3 crushed limestone aggregate or crushed stone containing at least 18% low plasticity fines may also be used. Material should be approved by the geotechnical engineer.

4.2.4 Compaction Requirements

Item		Description
Fill Lift Thickness [1]		9 inches or less in loose thickness
Compaction Requirements [2]		95% of the material's maximum standard Proctor dry density [3]
Moisture Content Clay Soil	**LL<40**	-2% to +2% of optimum moisture content value [3]
	LL>40	0 to 4% above the optimum moisture content value [3]
Moisture Content Granular Material		Workable moisture levels [4]

1. Reduced lift thicknesses are recommended in confined areas (e.g., utility trenches,

foundation excavations, and foundation backfill) and when hand-operated compaction equipment is used.

2. We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
3. As determined by the standard Proctor test (ASTM D 698).
4. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

4.2.5 Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, attempts should be made to limit the amount of fine migration into the clean stone. Fine migration into clean granular fill may result in unanticipated localized settlements over a period of time. To help limit the amount of fine migration, Terracon recommends the use of a geotextile fabric that is designed to prevent fine migration in areas of contact between clean stone and fine-grained soils. Terracon also recommends that clean stone be tracked or tamped in place where possible in order to limit the amount of future densification which may cause localized settlements over time.

Utility trenches are common sources of water infiltration and migration. All utility trenches that penetrate beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the building. We recommend constructing an effective “trench plug” that extends at least 5 feet out from the face of the building exterior. The plug material should consist of lean clay compacted at a water contact at or above the soil’s optimum water content. The lean clay fill should be placed to completely surround the utility line and be compacted in accordance with the recommendations in this report.

4.2.6 Grading and Drainage

Final grade should slope away from the structure on all sides to prevent ponding of water. If the green roof contains gutters and downspouts, they should drain water a minimum of 10 feet beyond the footprint of the rostrum. This can be accomplished through the use of splash-blocks, downspout extensions, and flexible pipes that are designed to attach to the end of the downspout. Flexible pipe should only be used if it is daylighted in such a manner that it gravity-drains collected water. Splash-blocks should also be considered below hose bibs and water spigots.

4.2.7 Earthwork Construction Considerations

In periods of dry weather, the surficial soils may be of sufficient strength to allow fill construction on the stripped and grubbed ground surface. However, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wet or subjected to repetitive construction traffic. The use of low ground pressure construction equipment would aid in reducing subgrade disturbance. The use of remotely operated equipment, such as a backhoe, would be beneficial to perform cuts and reduce subgrade disturbance. If unstable subgrade conditions be encountered, stabilization measures, as described in section **4.2.2 Soil Stabilization** will need to be employed.

Temporary excavations will probably be required during grading operations. The grading contractor is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

The contractor is responsible for selecting and implementing the appropriate dewatering procedures, if required during construction. Although groundwater was not encountered in the borings at depths expected to affect foundation excavations, it may be encountered during foundation excavation or in other excavation activities. In addition, some surface and/or perched groundwater may enter foundation excavations during construction. The volume of water seepage into shallow isolated excavations may be controllable with an appropriate number of sump pits and pumps; however, more extensive dewatering and/or subgrade stabilization may be required to facilitate construction if larger and/or deeper areas of cut are performed during earthwork operations.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of slabs and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to foundation construction.

Trees or other vegetation whose root systems have the ability to remove excessive moisture from the subgrade and foundation soils should not be planted next to the structure. Trees and shrubbery should be kept away from the exterior of the structure a distance at least equal to their expected mature height.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of slabs.

4.3 Foundations

The rostrum renovations can be supported using a shallow foundation system bearing on suitable native soils, newly placed engineered fill above suitable native soils, or bedrock. As is outlined in **Section 4.1.1 Shallow Bedrock Considerations**, foundations should bear on either soil or bedrock. Shallow foundation system design recommendations for the proposed structure are presented in the following sections.

4.3.1 Foundation Design Recommendations

Description	Column
Suitable bearing materials	Native very stiff to hard clay or new engineered fill extending to suitable native soil or bedrock
Net allowable bearing pressure [1,2] ■ Native Soil/Engineered Fill ■ Bedrock	 3,000 psf[2] 6,000 psf
Minimum width [6]	30 inches
Maximum dimension	8 feet
Minimum embedment below finished grade[3]	30 inches
Estimated total settlement from foundation loads [4]	up to1 inch
Estimated differential settlement from foundation loads [4]	<½ inch between columns
Ultimate passive pressure [5]	150 pcf, equivalent fluid density
Ultimate coefficient of sliding friction [5]	0.30

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation, and can be increased by 1/3 for transient loads (e.g., wind or seismic). Assumes the bearing material consists of suitable medium stiff to stiff native soil or structural fill.
2. Assumes any unsuitable existing fill or soft soils, if encountered, will be undercut and replaced with compacted structural fill.
3. For frost protection and to reduce the effects of seasonal moisture variations in the subgrade soils. For perimeter footing and footings beneath unheated areas.
4. Column foundations greater than 8 by 8 feet or strip wall foundations wider than 4 feet are estimated to settle 1 inch or greater if placed on native soils. Assumes the foundations do not bear on, or above the existing undocumented fill. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted fill, and the quality of the earthwork operations. If aggregate piers are used, the predicted settlement will be provided by the designer.
5. Passive resistance in the upper 30 inches of the soil profile should be neglected. Some movement of the footing will be required to mobilize resistance from passive pressure and sliding friction.
6. Minimum width assumes foundations are bearing on soil and is not applicable if bearing on bedrock.

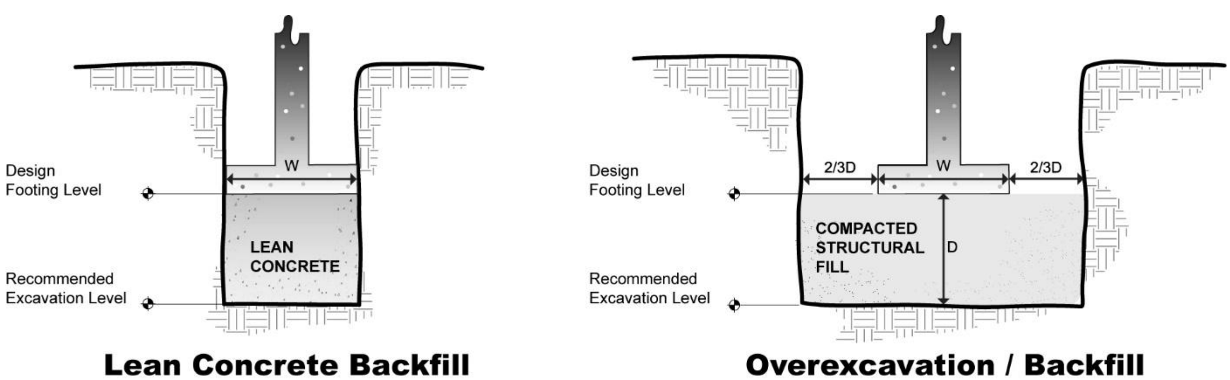
Uplift resistance for spread footing foundations may be computed as the sum of the weight of the foundation element and the weight of the soil overlying the foundation. We recommend using a soil unit weight of 110 pounds pcf for compacted structural fill overlying the footing placed as described in section **4.2 Earthwork**. A unit weight of 150 pcf could be used for reinforced footing concrete. We recommend a minimum factor of safety of 1.5 be utilized for uplift calculations.

4.3.2 Foundation Construction Considerations

The base of each foundation excavation should be free of water, undocumented fill, soft native soil, and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. If the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete. Place a lean concrete mud-mat over the bearing soils if the excavations must remain open over night or for an extended period of time. It is recommended that the geotechnical engineer be retained to observe and test the soil foundation bearing materials.

Although groundwater was not encountered in the borings at depths expected to affect foundation excavations, it may be encountered during foundation excavation or in other excavation activities. In addition, some surface and/or perched groundwater may enter foundation excavations during construction. It is anticipated any water entering foundation excavations from these sources can be removed using sump pumps or gravity drainage.

If unsuitable bearing soils (e.g., undocumented fill or soft native soils) are encountered in footing excavations, the excavation could be extended deeper to suitable soils and the footing could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative, the footings could also bear on properly compacted structural backfill extending down to the suitable soils. Overexcavation for compacted structural fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled per recommendations provided in section **4.2 Earthwork** up to the footing base elevation. The overexcavation and backfill procedure is described in the following figure.



NOTE: Excavations in sketches shown vertical for convenience. Excavations should be sloped as necessary for safety.

4.3.3 Interaction Between New and Existing Structures

Care should be taken to not disturb the bearing soils beneath the existing rostrum foundations and slabs. It is recommended, where possible, that excavations below these elements not extend below an imaginary plane extending out and down from the outside edge of existing footings, grade beams, and/or slabs at a slope of approximately 2H:1V. Even with these criteria, excavations that extend below the level of existing structures should be backfilled the same day they are excavated. Where this is impractical, shoring or underpinning of existing foundations may be required to resist undermining or movement of the existing structures.

Existing fill in excavations near the existing buildings should also be anticipated. It should be noted that the backfill for the existing foundations may not have been placed in accordance with the recommendations provided in this report, and should not be used for foundation support.

Some overlap in stress distribution from new and existing footings may occur, which may cause some movement of the existing footings and the supported rostrum. Maintaining a clear distance at least equal to the width of the new spread footings between the edges of the new and existing footings could reduce this risk. Connections between the new and existing structures should be designed to allow for the anticipated differential movement. Differential settlement between new and existing structures may approach the estimated total settlement, unless the foundations are structurally tied together.

4.4 Grade-Supported Slabs

If undocumented fill is encountered, the undocumented fill should be removed and replaced within the footprint of the proposed structure. Grade-supported slabs should be supported on a minimum of 24 inches of LVC material. LVC fill should be placed and compacted as recommended in section **4.2 Earthwork**.

4.4.1 Slab Design Recommendations

Item	Description
Slab support [1, 2]	A minimum 24-inch thick low volume change (LVC) layer over suitable native clay or engineered fill
Modulus of subgrade reaction	100 pounds per square inch per inch (psi/in) for point loading conditions
Granular course beneath slab [3, 4, 5]	Minimum 4 inches
Capillary break layer thickness [4, 5]	Minimum 6 inches

1. We recommend an LVC layer be present below the slab. This layer should be at least 24 inches thick and should meet the LVC material criteria outlined in this report in section **4.2 Earthwork**. Where existing soils meet the LVC criteria, they should be moisture conditioned and recompacted as recommended in this report.

2. We recommend subgrades be maintained in a relatively moist condition until the slab is constructed. If the subgrade should become desiccated prior to construction of slab, the affected material should be removed or the materials scarified, moistened, and recompacted. Upon completion of grading operations in the building area, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building slab.
3. If the purpose of this layer is solely to create a level base for concrete placement to maintain a more uniform slab thickness, well-graded sand, gravel or crushed stone can be used.
4. If penetration of moisture vapor through the slab is a concern, in our opinion the slab design should include a capillary break layer in addition to a vapor retarder (refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of vapor retarders). In our opinion, capillary break layers should be comprised of granular materials that have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant addition design considerations.
5. These granular materials may be considered part of the LVC zone.

Where appropriate, saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks in slabs that develop should be sealed with a water-proof, non-extruding compressible compound specifically recommended for concrete and wet environments.

The use of a vapor retarder should be considered beneath concrete slabs-on-grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

4.4.2 Slab Construction Considerations

On most project sites, the site grading is generally accomplished early in the construction phase. However as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, rainfall, etc. As a result, the slab subgrade may not be suitable for placement of base rock and concrete and corrective action will be required.

Prior to placement of the base aggregate, we recommend that the slab subgrade be rough graded and then thoroughly evaluated for stability, uniformity and moisture condition. If there is no conflict with installed utilities, we recommend the subgrade be proofrolled with a loaded, tandem-axle dump truck. During the evaluations, particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted fill. All slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the aggregate base and concrete.

4.5 Seismic Considerations

Code Used	Site Classification
2009 International Building Code (IBC) [1]	C [2]

1. In general accordance with the *2009 International Building Code,* Table 1613.5.2.
2. The 2009 International Building Code requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100 foot soil profile determination. Borings for this report extended to a maximum depth of approximately 5 feet and the site classification assumes that bedrock extends to at least 100 feet.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION

Field Exploration Description

The boring locations were laid out in the field using a scaled site plan provided by the client and referencing available site features. Angles were estimated. The ground surface elevations at the boring locations were provided by the site surveyor and are rounded to the nearest ½-foot. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

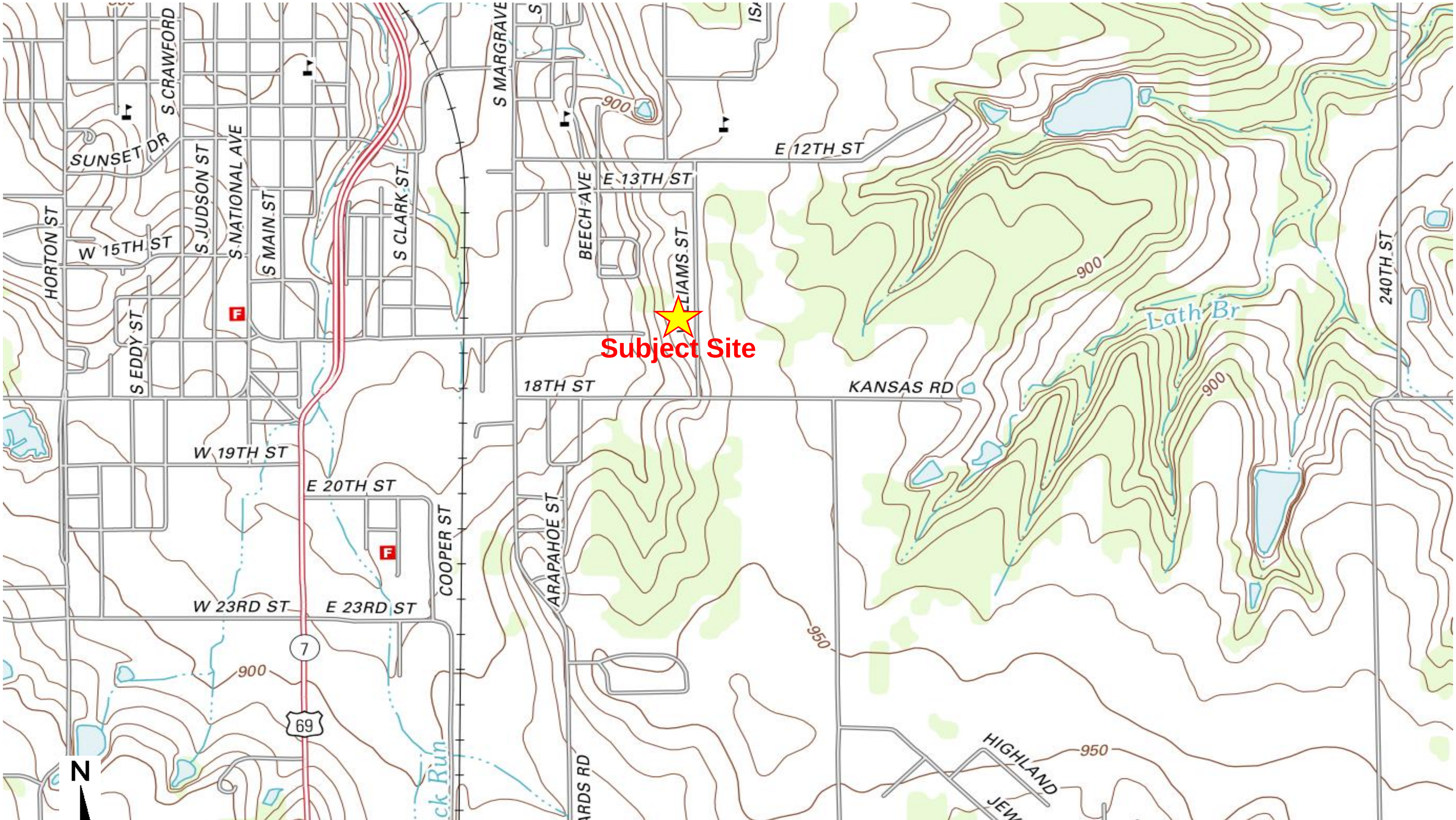
The borings were drilled with an ATV-mounted rotary drill rig using continuous-flight hollow-stem augers to advance the boreholes through soils. Samples of the soil encountered in the borings were obtained using the split-barrel procedures.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils.

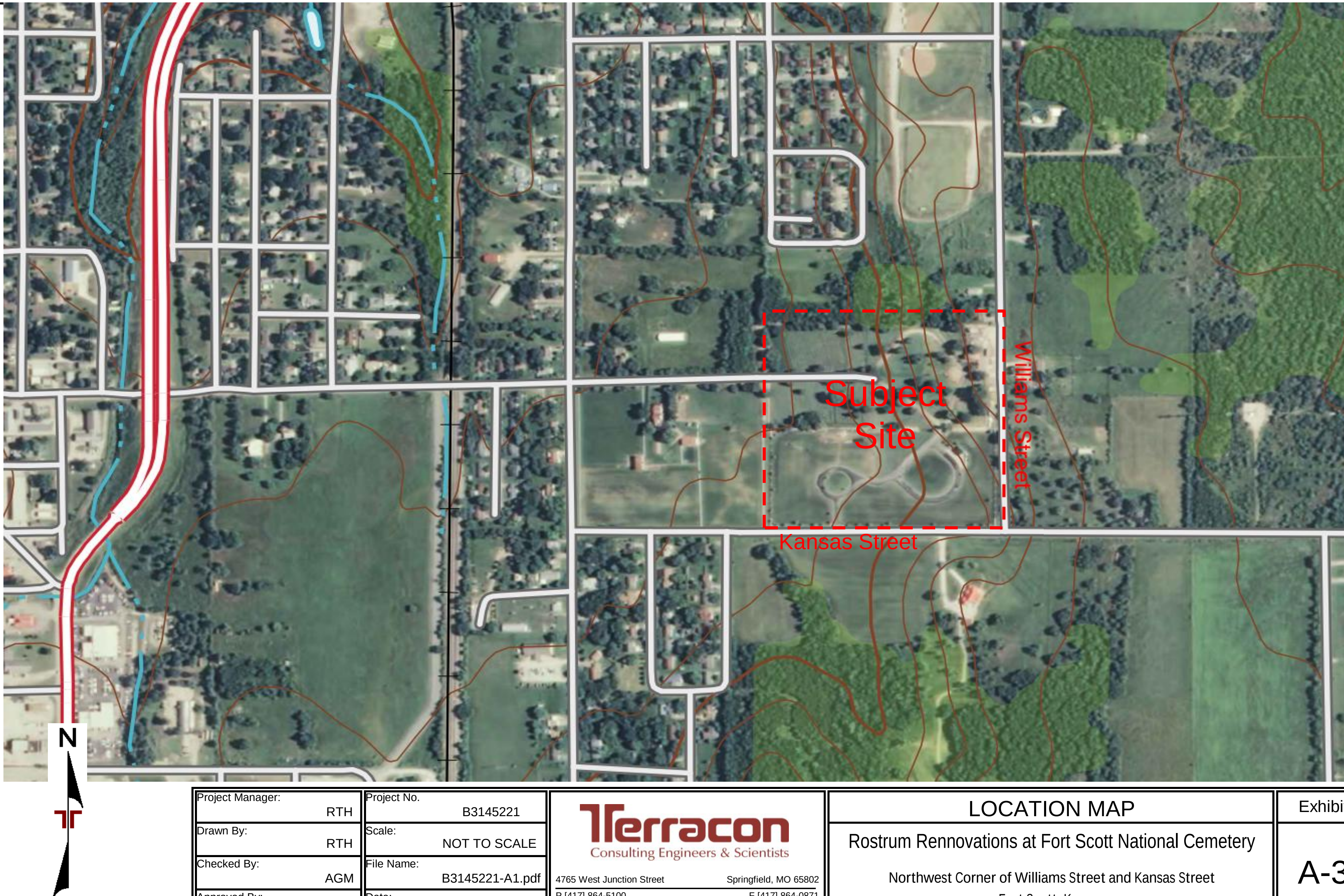
A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of this efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.



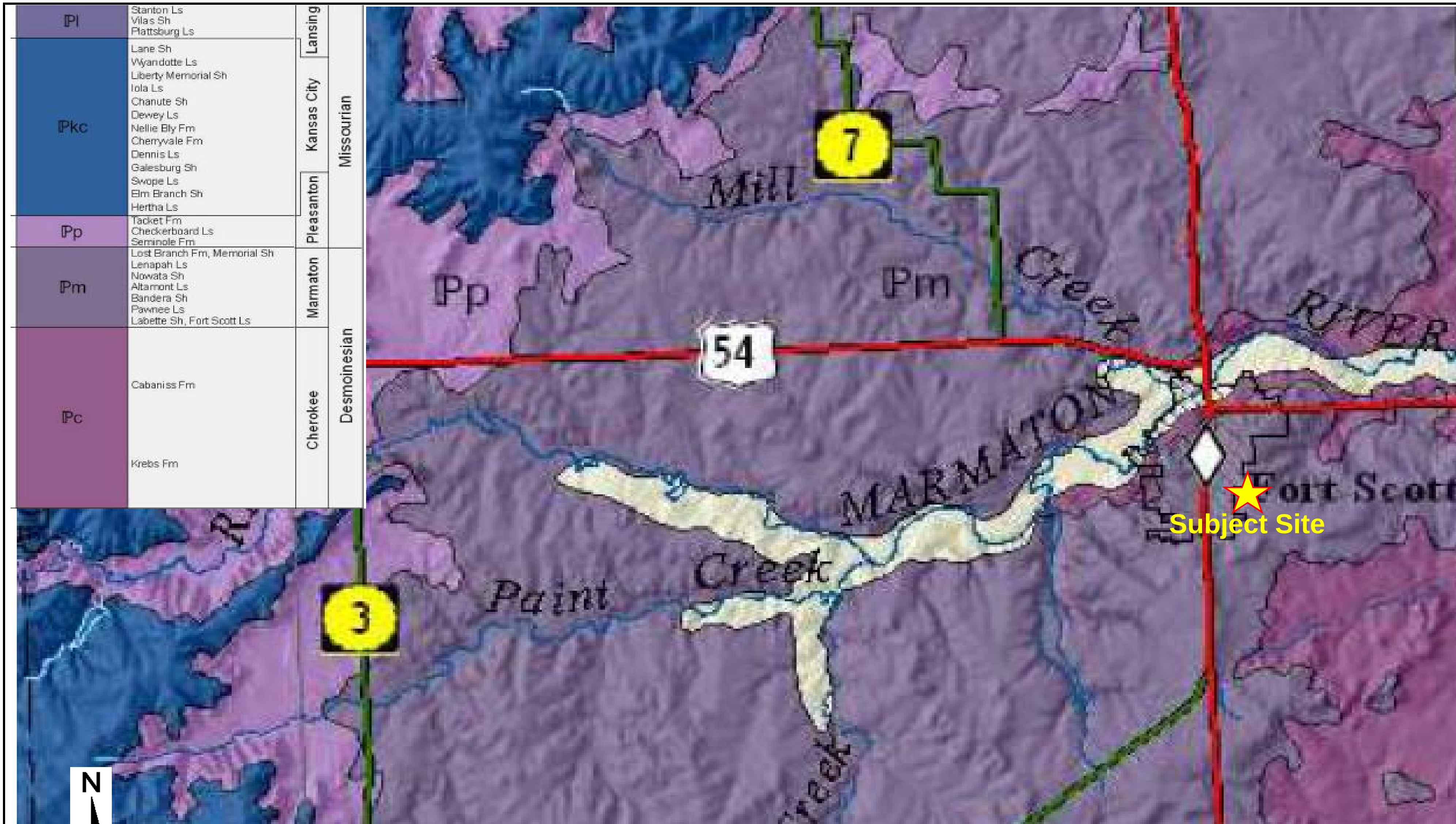
Project Manager: RTH	Project No. B3145221	Terracon Consulting Engineers & Scientists	TOPOGRAPHIC MAP	Exhibit
Drawn By: RTH	Scale: NOT TO SCALE	4765 West Junction Street Springfield, MO 65802	Rostrum Rennovations at Fort Scott National Cemetery	A-2
Checked By: AGM	File Name: B3145221-A1.pdf	P [417] 864-5100 F [417] 864-0871	Northwest Corner of Williams Street and Kansas Street	
Approved By: AGM	Date: 9/29/2014		Fort Scott, Kansas	



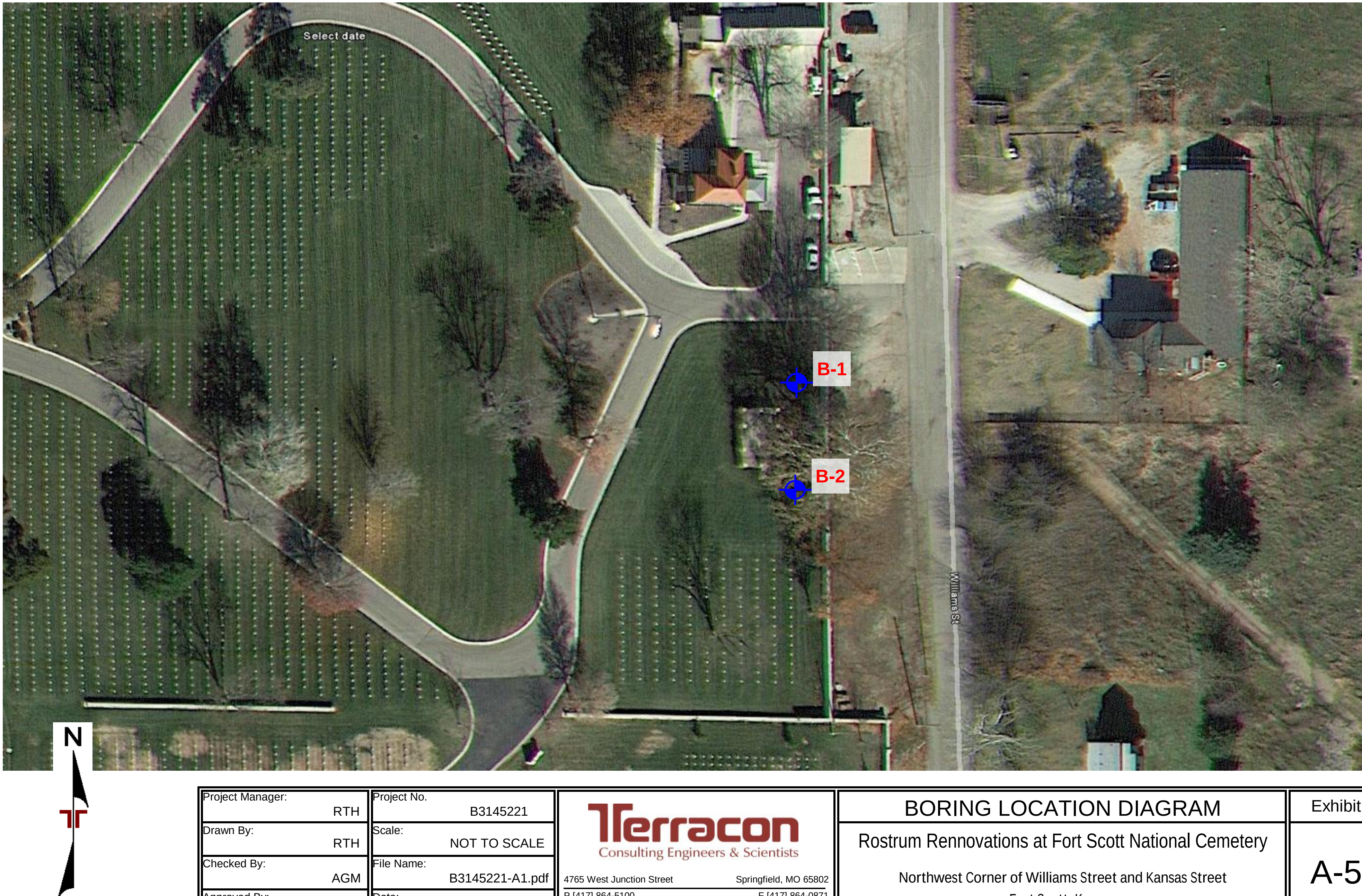
Project Manager: RTH	Project No. B3145221	Terracon Consulting Engineers & Scientists	LOCATION MAP
Drawn By: RTH	Scale: NOT TO SCALE		Rostrum Rennovations at Fort Scott National Cemetery
Checked By: AGM	File Name: B3145221-A1.pdf	4765 West Junction Street Springfield, MO 65802	Northwest Corner of Williams Street and Kansas Street
Approved By: AGM	Date: 9/29/2014	P [417] 864-5100 F [417] 864-0871	Fort Scott, Kansas

Exhibit

A-3



Project Manager: RTH	Project No. B3145221	Terracon Consulting Engineers & Scientists	GEOLOGIC MAP	Exhibit
Drawn By: RTH	Scale: NOT TO SCALE		Rostrum Rennovations at Fort Scott National Cemetery	A-4
Checked By: AGM	File Name: B3145221-A1.pdf	4765 West Junction Street Springfield, MO 65802	Northwest Corner of Williams Street and Kansas Street	
Approved By: AGM	Date: 9/29/2014	P [417] 864-5100 F [417]-864 0871	Fort Scott, Kansas	



Project Manager: RTH	Project No. B3145221	Terracon Consulting Engineers & Scientists	BORING LOCATION DIAGRAM
Drawn By: RTH	Scale: NOT TO SCALE	4765 West Junction Street Springfield, MO 65802	Rostrum Rennovations at Fort Scott National Cemetery
Checked By: AGM	File Name: B3145221-A1.pdf	P [417] 864-5100 F [417] 864-0871	Northwest Corner of Williams Street and Kansas Street Fort Scott, Kansas
Approved By: AGM	Date: 9/29/2014		Exhibit A-5

BORING LOG NO. B-1

PROJECT: Rostrum Renovations at Fort Scott National Cemetery

CLIENT: FourFront Design, Inc.
517 Seventh Street - Rapid City, South Dakota

SITE: NEC of Kansas Road and Williams Street
Fort Scott, Kansas

LOCATION See Exhibit A-2

Latitude: 37.8214° Longitude: -94.6923°

Approximate Surface Elev: 931 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.7	**TOPSOIL**	930.5+/-								
3.0	**FAT CLAY (CH)**, with gravel and cobbles, dark brown, very stiff to hard	928+/-			X	10	10-15-50/2"	9000 (HP)	28	
5.2	**LIMESTONE**, gray, moderately weathered	926+/-	5		X	3	50/5"		1	
					X	2	50/2"		2	
	Auger Refusal at 5.2 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic SPT Hammer

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 9/9/2014	Boring Completed: 9/9/2014
Drill Rig: CME-550X	Driller: S. Becker
Project No.: B3145221	Exhibit: A-6

BORING LOG NO. B-2

PROJECT: Rostrum Renovations at Fort Scott National Cemetery

CLIENT: FourFront Design, Inc.
517 Seventh Street - Rapid City, South Dakota

SITE: NEC of Kansas Road and Williams Street
Fort Scott, Kansas

LOCATION See Exhibit A-2

Latitude: 37.8213° Longitude: -94.6923°

Approximate Surface Elev: 931 (Ft.) +/-

DEPTH	Material Description	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.3	**TOPSOIL**	930.5+/-							
3.0	**FAT CLAY (CH)**, with gravel and organics, very stiff	928+/-		X	12	10-15-30 N=45	6000 (HP)	24	56-27-29
4.5	**LIMESTONE**, gray, moderately weathered	926.5+/-		X	3	25-50/2"		8	
	Auger Refusal at 4.5 Feet				0	50/0"			

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic SPT Hammer

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 9/9/2014	Boring Completed: 9/9/2014
Drill Rig: CME-550X	Driller: S. Becker
Project No.: B3145221	Exhibit: A-7

APPENDIX B
SUPPORTING INFORMATION

Laboratory Testing

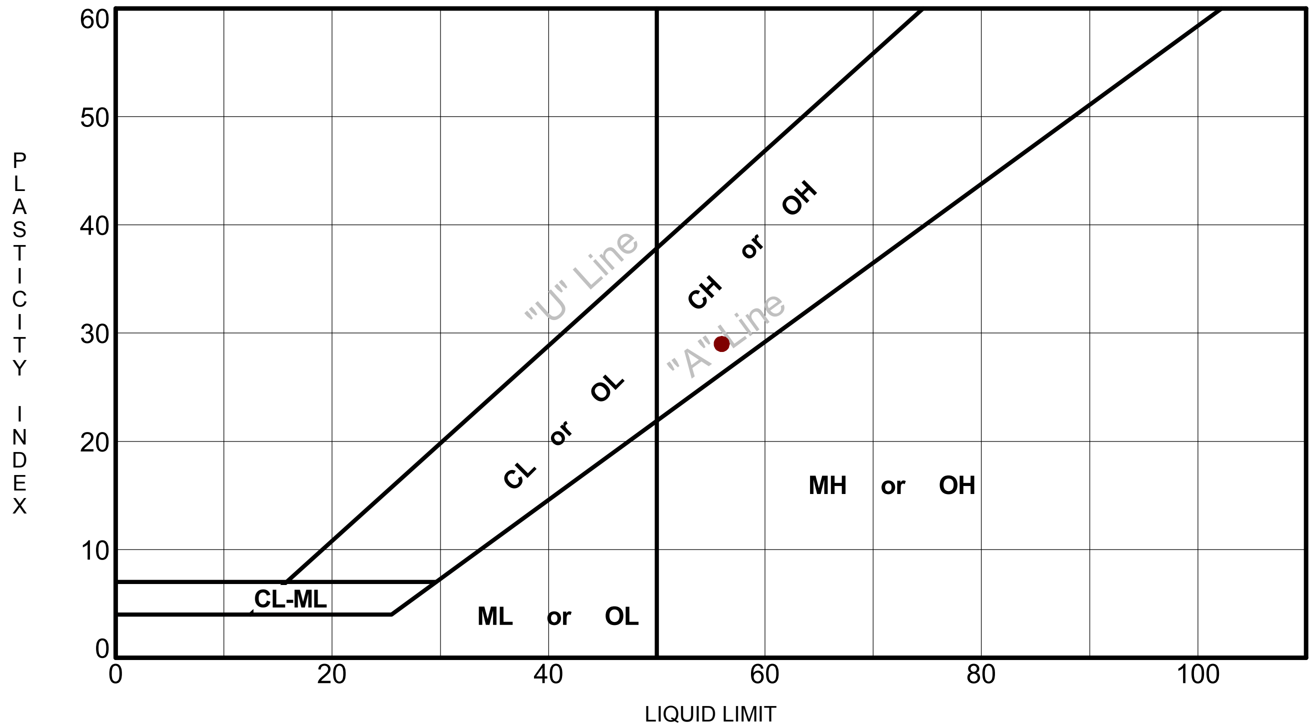
Soil samples were tested in the laboratory to measure their natural water content (ASTM D4959). A hand penetrometer was used to estimate the unconfined compressive strength of some cohesive samples. The hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone. The test results are provided on the boring logs included in Appendix A.

As part of the testing program, samples were examined in our laboratory and classified in accordance with the General Notes and the Unified Soil Classification System (USCS) based on the material's texture and plasticity (ASTM D2487 and ASTM D2488). The USCS group symbol is shown on the boring logs, and a brief description of the USCS is included with this report in Appendix C.

Procedural standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● **B-2**	**1.0**	**56**	**27**	**29**		**CH**	**Fat clay**

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	Split Spoon
Shelby Tube	Macro Core
Ring Sampler	Rock Core
Grab Sample	No Recovery

WATER LEVEL

Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

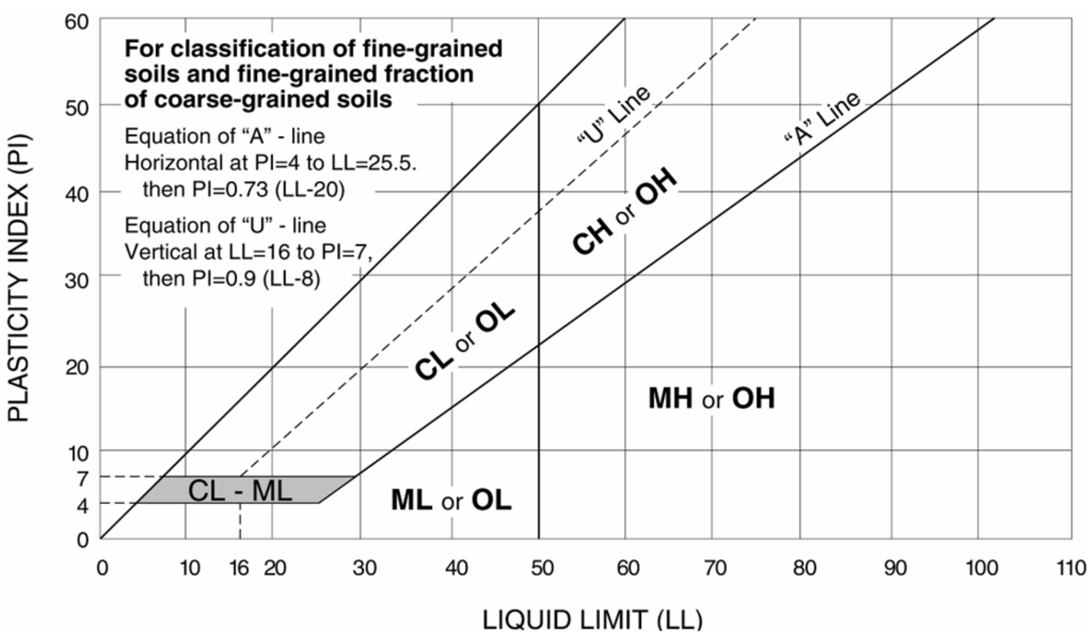
UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	$PI > 7$ and plots on or above “A” line [J]		CL	Lean clay [K,L,M]
			$PI < 4$ or plots below “A” line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K,L,M]
			PI plots below “A” line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 15% sand, add “with sand” to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add “with organic fines” to group name.
[I] If soil contains $\geq$ 15% gravel, add “with gravel” to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.
[L] If soil contains $\geq$ 30% plus No. 200 predominantly sand, add “sandy” to group name.
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.
[N] $PI \geq 4$ and plots on or above “A” line.
[O] $PI < 4$ or plots below “A” line.
[P] PI plots on or above “A” line.
[Q] PI plots below “A” line.



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DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, PSI (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft (50 – 300 mm)
Moderate	8 in – 2 ft (200 – 600 mm)	**Medium**	1 ft – 3 ft (300 – 900 mm)
Wide	2 ft – 6 ft (600 mm – 2.0 m)	**Thick**	3 ft – 10 ft (900 mm – 3 m)
Very Wide	6 ft – 20 ft (2.0 – 6 m)	**Massive**	> 10 ft (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0 degree angle.

ROCK QUALITY DESIGNATION (RQD*)	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

*The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements